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PRODUCT IMPROVEMENT TEST OF T53-L-11 ENGINE IN THE UH-1D HELICOPTER.

(9) Final Report of Test

by

(10) Mr. Clyde H. Davis
Mr. F. J. McCrory

(11) 5 April 1966

(12) 41 p.

DEPARTMENT OF THE ARMY
UNITED STATES ARMY AVIATION TEST BOARD
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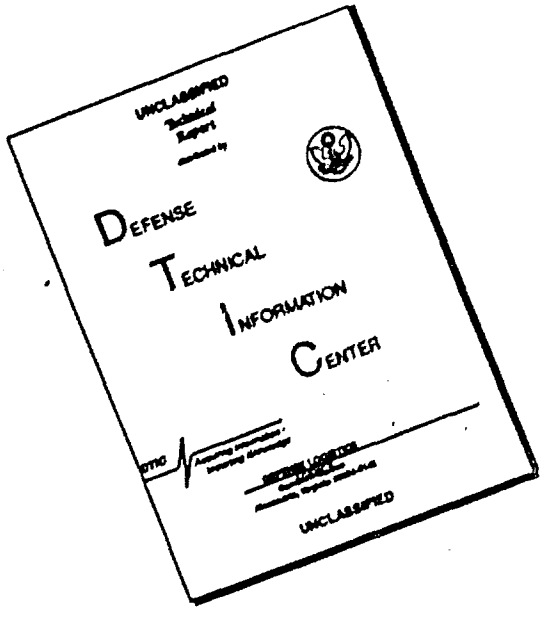

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RDT&E PROJECT NO. Unknown
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"PRODUCT IMPROVEMENT TEST OF T53-L-11 ENGINE IN THE UH-1D HELICOPTER"

Final Report of Test

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APPROVED:

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ABSTRACT

As a result of the unsatisfactory performance of certain T53-L-11 engine components, the USAAVNTBD was requested to conduct a product improvement test of improved components on a T53-L-11 engine installed in a UH-1D Helicopter during the period June 1964 to December 1965. The test was terminated at the end of 941 hours of operation owing to damage resulting from failure of a bearing not being tested. It was concluded that the product-improvement items found suitable as replacements for the standard items in the T53-L-11 engine are the combustor deflector, gas-producer turbine wheel, exhaust diffuser, power turbine nozzle, and asbestos air seal; that other samples of the combustor liner mounting system should be tested to analyze further the cause of the one bracket failure; that the suitability of the product-improvement main-shaft carbon seal, No. 2 and No. 3 main-shaft bearings, and power turbine wheel cannot be determined because of damage sustained when the No. 4 bearing failed; and that the suitability of the design to air-seal segments to keep walnut-shell compound from lodging between segments cannot be determined because the engine was not cleaned with the walnut-shell compound. It is recommended that the product-improvement combustor deflector, gas-producer turbine wheel, stainless-steel exhaust diffuser, power turbine nozzle, and asbestos air seal be adopted as standard and incorporated in the T53-L-11 engines during production or overhaul; that additional samples of the product-improvement main-shaft carbon seal, combustor liner mounting system, No. 2 and No. 3 main-shaft bearings, and power turbine wheel be subjected to a 1200-hour test; and that the test of the air-seal system segments be continued to include cleaning the engine with walnut-shell cleaning compound.

FOREWORD

The Commanding General, US Army Test and Evaluation Command, directed product improvement tests of various components and parts of the UH-1D in letter, AMSTE-BG, Headquarters, US Army Test and Evaluation Command, 27 January 1965, subject: "Test Directive, USATECOM Project No. 4-5-0151-( ), Product Improvement Test, UH-1D Items." In the US Army Test and Evaluation Command Project Transcript Sheet, 4 February 1965, USATECOM Project No. 4-5-0151-01 was assigned to the test of the T53-L-11 engine product-improvement items.

The US Army Aviation Test Board (USAAVNTBD) was responsible for preparing the test plan, for conducting the test, and for preparing the test report.

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SECTION 1 - INTRODUCTION

INTRODUCTION

1.1. BACKGROUND AND DESCRIPTION OF MATERIEL.

The UH-1D Helicopter was type classified Standard A in September 1962. Product improvement of the UH-1D has been and is a continuous process as the result of testing, service-incurred difficulties, and research and development by the airframe and engine manufacturers. To reduce cost and weight and to increase service life, certain components of the T53-L-11 gas turbine engine have been modified.

1.1.1. Combustor Deflector, P/N 1-110-440-102, FSN 2840-872-6126.

The combustor deflector, located in the combustion section, deflects the gas stream 180 degrees into the gas-producer (N_1) nozzle. The standard deflector is a rigid two-piece welded assembly. A significant number of deflectors in the field cracked at the center electric weld because of uneven stress. The modified deflector was developed to eliminate the problem by reducing the susceptibility of the deflector to cracking and incorporates a bellows-type insert which provides flexibility to the assembly.

1.1.2. Gas-Producer Turbine Wheel, P/N 1-100-490-06, FSN 2840-022-7501.

The gas-producer (N_1) turbine wheel is mechanically coupled to and drives the compressor. The standard turbine-wheel blades incorporate an extensive hollow-core area in each blade. The standard blades have a history of chord-wise cracking in the lower root area, angular cracking of the trailing edge, and tip cracking in the core area. The modified assembly incorporates thicker-walled turbine blades (P/N 1-100-428-11, FSN 2840-736-8754) to reduce the frequency of cracking.

1.1.3. Combustor Liner Mounting System (Flexible Studs PSK-8254, P/N 1-110-440-02, FSN 2840-793-2065; Solid Suspension Studs PSK-8094, P/N 1-130-410-10, FSN 2840-953-4970).

The combustor liner is held in place in the combustion chamber by eleven mounting studs arranged in a circular pattern. The standard combustor liner mounting system has failed numerous times because

of wearing of the liner brackets which resulted from friction between the combustor liner mounting brackets and mounting studs. These failures permitted the liner to float freely. Some degree of flexibility is necessary in the mounting system because of the pulsating vibrations produced by combustion. Flexible and solid suspension systems that have been previously tested have proved unsatisfactory to reduce wear. The heads of the studs in the product-improvement system have been beveled to reduce wear caused by friction. Eight of the studs have been modified by the addition of a bushing, designed to provide flexibility to the combustor liner. The remaining three studs, installed 120 degrees apart, are torqued solidly against the liner bracket to provide a damping action to the liner flexibility.

1.1.4. Main-Shaft Carbon Seal, P/N 1-300-214-01, No Federal Stock Number.

The main-shaft carbon seal, located at the No. 3 bearing, prevents the leakage of air into the bearing area and the loss of oil pressure. Although the standard one-piece seal is reliable, it is not repairable and is a relatively high-cost item. The modified seal, developed to reduce costs and increase field maintainability, incorporates nine segmented pieces and is repairable at the direct- and general-support categories of maintenance.

1.1.5. No. 2 and No. 3 Main-Shaft Bearings, P/N 1-300-013-05 (SKF-457798), FSN 3110-869-7151.

The No. 2 main-shaft bearing is the support bearing for the gas-producer (N_1) turbine assembly. The No. 3 main-shaft bearing is the support bearing for the power turbine (N_2) assembly. The standard No. 2 and No. 3 bearings incorporate bronze cages which have a history of uneven wear in the area of the pockets because the pocket lip tends to wipe the lubricant from the rollers during starting. Also, the bronze cage pockets are difficult to machine because of the precision required of the lip angle. The modified bearings incorporate an improved-steel (AMC 6415), silver-flashed cage with a modified pocket angle designed to reduce wear and to make pocket lip angles easier to machine.

1.1.6. Exhaust Diffuser, P/N 1-150-200-01, FSN 2840-792-5401.

The exhaust diffuser supports the No. 3 and No. 4 bearing housings and power turbine nozzle, and acts as an exit guide path for

the exhaust gases. The standard diffuser has experienced heavy rusting in the area of the exhaust pipe mounting flange, and requires an extensive heat-treat cycle because of the welding method used. The stainless-steel diffuser was designed to eliminate the rusting and to require a less extensive heat-treat cycle.

1.1.7. Power Turbine Nozzle, P/N 1-140-420-04, FSN 2840-085-3880.

The power turbine nozzle receives gases under high pressure and velocity from the gas-producer (N_1) turbine and redirects these gases at the correct angle to the power turbine wheel (N_2). The standard nozzle incorporates a steel shroud and the nozzle vane-shroud joints have cracked. The steel support cannot be repaired by brazing and, therefore, repairs were made by welding. The welding repair procedure, however, has often resulted in distortion of the nozzle and warping of the flange beyond tolerances. The modified nozzle incorporates a support constructed of a materiel which can be repaired using a vacuum-braze procedure. This should result in cost reduction and permit the depot repair of a higher percentage of nozzles.

1.1.8. Power Turbine Wheel (N_2), P/N 1-140-210-11, FSN 2840-475-6948.

The power turbine wheel, which is driven by gases received from the power turbine nozzle, drives the power train. The standard turbine wheel blades have experienced blade "growth" (span-wise expansion of a turbine blade) after the initial test cell run. This growth has often required extensive regrinding to bring the blade dimensions within limits. The modified turbine wheel incorporates turbine blades which have been subjected to an extensive, controlled, heat-treat cycle and have acquired maximum growth prior to installation.

1.1.9. Asbestos Air Seal, P/N 1-300-052-01, No Federal Stock Number.

The asbestos air seal, located at the combustion chamber flange, seals the combustion chamber. The asbestos materiel of the standard air seal has separated from the wire mesh, resulting in destruction of the exposed wires due to high temperatures. Destruction of the seal caused increased exhaust gas temperature (EGT). The modified seal was developed to minimize seal destruction and resultant

gas leakage and incorporates a mesh using wire with a larger diameter.

1.1.10. Air-Seal Segments (PSK-8452), P/N 1-140-222-02, FSN 2840-736-3996.

Twelve air-seal segments are installed to retain the asbestos gas seal in the power turbine nozzle-retention assembly. With the standard subassembly installed, a maximum permissible space of 0.080 inch existed between adjacent segments. The total possible clearance was 0.420 inch. When the engine was cleaned with a walnut-shell compound, small pieces of the compound filled in the space between segments and subsequently worked in behind the segments. When subjected to high temperatures, the cleaning compound burned, reducing the tension of the positioning springs and permitting the segments to release the pressure on the gas seal. The modified segments have been lengthened and the space between segments reduced so that the total possible clearance is now 0.060 inch. This should prevent the cleaning compound from lodging between and behind the segments.

1.2. TEST OBJECTIVES.

1.2.1. Purpose.

To develop for and provide to the Iroquois Project Manager the results of operational experience on new or modified T53-L-11 engine product-improvement items.

1.2.2. Objectives.

To determine the suitability of the following modified items:

a. Combustor deflector.

b. Gas-producer turbine wheel.

c. Combustor liner mounting system.

d. Main-shaft carbon seal.

e. No. 2 and No. 3 main-shaft bearings.

f. Exhaust diffuser.

g. Power turbine nozzle.

h. Power turbine wheel.

i. Asbestos air seal.

j. Air-seal segments.

1.3. SUMMARY OF RESULTS.

The following are based on 941 flight test hours, at which time the No. 4 bearing failed, terminating the test.

1.3.1 The combustor deflector contained several small cracks in the spot weld area of the inner flange; however, the assembly was considered to be serviceable at the end of test.

1.3.2. The blades of the gas-producer turbine wheel sustained minor erosion but the wheel was serviceable at the end of test. The thicker walls of the wheels alleviated the cracking problem.

1.3.3. A position bracket in the combustion liner mounting system was found to be broken at the end of test. No breaks had been observed until this time. The liner contained minor cracks in the area around the cooling holes on the inner walls.

1.3.4. The main-shaft carbon seal functioned without failure but was severely damaged when the No. 4 bearing failed.

1.3.5. The No. 2 bearing originally installed for test was returned to the manufacturer with the engine after 583 hours. The No. 2 bearing of the engine on which the remaining test items were installed operated for the remaining 358 test hours satisfactorily. The No. 3 bearing operated satisfactorily during the test but was damaged by the failure of the No. 4 bearing.

1.3.6. Although the stainless-steel exhaust diffuser was found to contain cracks in the strut fairing leading edge after 884 flight test hours and after 941 flight test hours, it was an improvement over the standard diffuser in that rusting did not occur during the test.

1.3.7. Although the power turbine nozzle contained minor cracks in the outer shroud vane brazements, it was an improvement over the standard item in that no cracks were found in the inner shroud.

1.3.8. Growth of the power turbine wheel blades could not be measured because of damage incurred by the wheel when the No. 4 bearing failed.

1.3.9. The asbestos air seal was serviceable at the end of test.

1.3.10. The air-seal segments were serviceable at the end of test; however, the engine was not cleaned during the test with walnut-shell compound because of the termination of the test.

1.4. FAILURE OF NO. 4 BEARING.

The manufacturer is still investigating the cause of the failure of the No. 4 main-shaft bearing. The No. 4 bearing was not an item undergoing test.

1.5. CONCLUSIONS.

1.5.1. The following previously-described product-improvement items are suitable as replacements for the standard items in the T53-L-11 engine:

a. Combustor deflector.

b. Gas-producer turbine wheel.

c. Exhaust diffuser.

d. Power turbine nozzle.

e. Asbestos air seal.

1.5.2. Other samples of the combustor liner mounting system should be tested to analyze further the cause of the one bracket failure.

1.5.3. The suitability of the following product-improvement items can not be determined because of damage sustained when the No. 4 bearing failed:

a. Main-shaft carbon seal.

b. No. 2 and No. 3 main-shaft bearings.

c. Power turbine wheel.

1.5.4. The suitability of the design of the air-seal segments to keep walnut-shell cleaning compound from becoming lodged between segments cannot be determined because the engine was not cleaned with walnut-shell compound.

1.6. RECOMMENDATIONS.

It is recommended that:

1.6.1. The following previously-described product-improvement items be adopted as standard and incorporated in the T53-L-11 engines during production or overhaul:

a. Combustor deflector.

b. Gas-producer turbine wheel.

c. Stainless-steel exhaust diffuser.

d. Power turbine nozzle.

e. Asbestos air seal.

1.6.2. Additional samples of the following product-improvement items be subjected to a 1200-hour test:

a. Main-shaft carbon seal.

b. Combustor liner mounting system.*

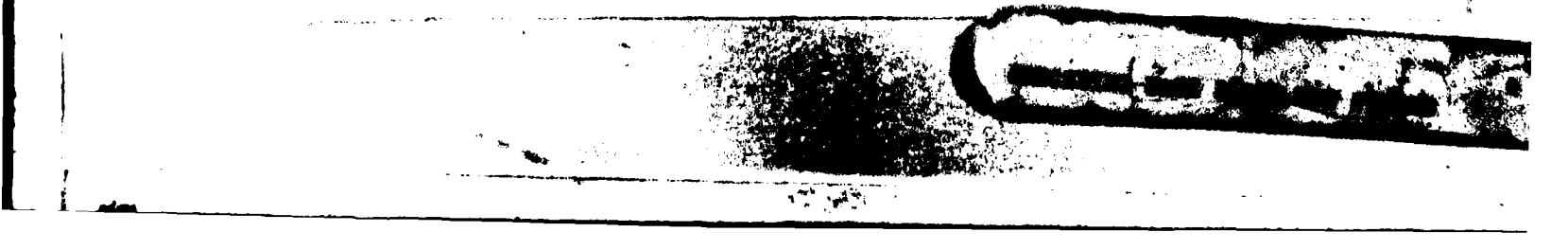
c. No. 2 and No. 3 main-shaft bearings.*

d. Power turbine wheel.*

1.6.3. The test of the air-seal system segments* be continued to include cleaning the engine with walnut-shell cleaning compound.

*Currently being tested under USATECOM Project No. 4-5-0101-01/06.

SECTION 2 - DETAILS AND RESULTS OF SUBTESTS



DETAILS AND RESULTS OF SUBTESTS

2.1. INTRODUCTION.

The product-improvement components of the T53-L-11 engine (LE-06005X) were tested at the USAAVNTBD from 15 June 1964 to 12 May 1965. At 583 engine hours, the compressor was replaced because of foreign object damage (FOD). The test was terminated when the engine experienced No. 4 bearing failure. The engine was returned to the manufacturer for tear-down analysis. The USAAVNTBD received the manufacturer's analysis in December 1965.

2.2. TESTS.

2.2.1. Objective.

To determine the suitability of each test item.

2.2.2. Method.

The test items were subjected to 941 hours of engine operation with the helicopter at high gross weights. All takeoffs were performed at a minimum of 40 p.s.i. torque, provided 638°C. EGT was not exceeded. At termination of the test, the product-improvement components were analytically inspected at the engine manufacturer's facility.

2.2.3. Combustor Deflector (Flexible Support).

2.2.3.1. Results.

The combustor deflector was in serviceable condition at the termination of test (figure 1). No cracks were evident in the center seam weld. There were several small cracks in the spot weld area of the inner flange (figure 2).

2.2.3.2. Analysis.

2.2.3.2.1. The combustor deflector is suitable and offers a definite improvement over the standard part (figure 3).

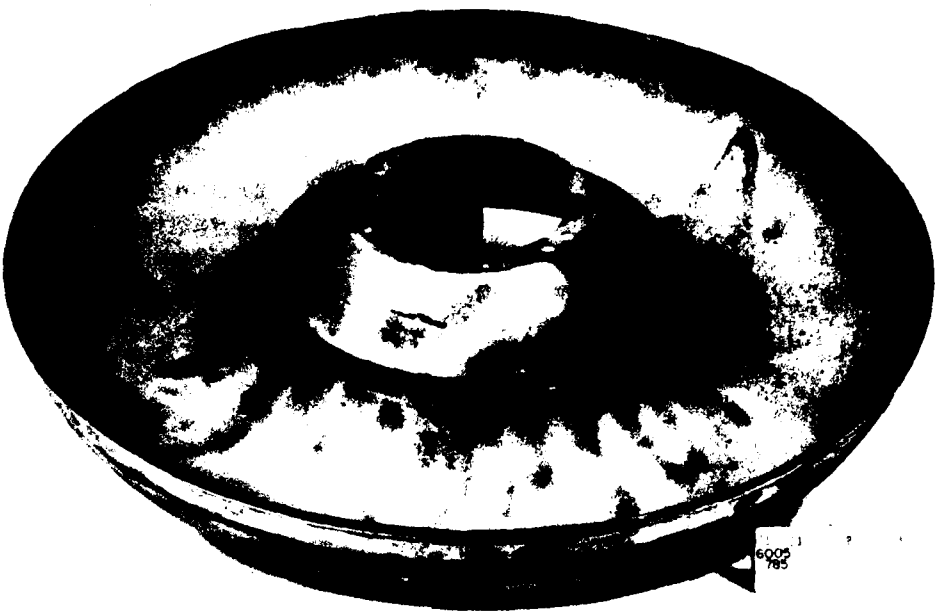
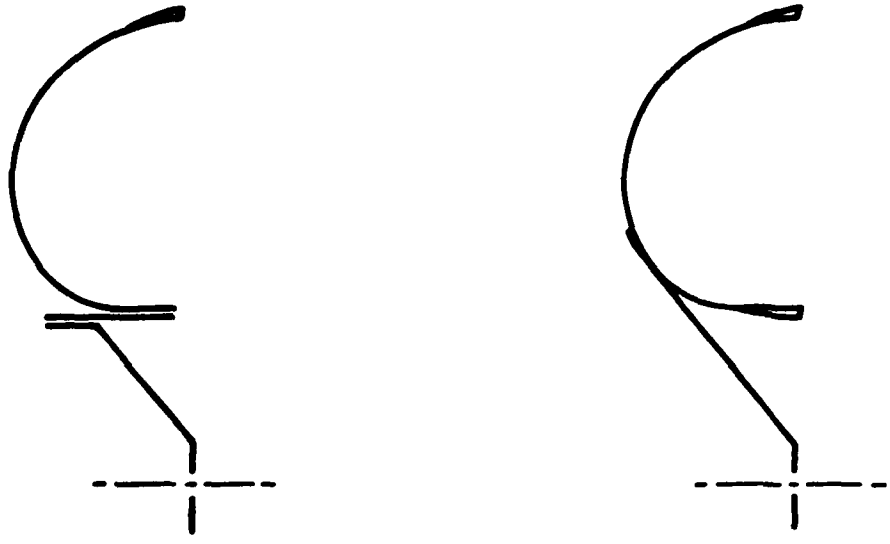


Figure 1. Combustor deflector at the end of test.

Figure 2. Inner flange of the combustor deflector.



FLEXIBLE COMBUSTOR CURL
1-110-440-02

RIGID COMBUSTOR CURL
1-110-020-02

Figure 3. The design of the product-improvement combustor deflector (left) and of the standard combustor deflector (right).

2.2.3.2.2. The manufacturer stated that test cell operation with parts containing minor cracks in the spot weld area has shown that such cracks do not affect the serviceability of the deflector. The manufacturer is presently establishing the serviceability limits for the new flexible deflector.

2.2.4 Gas-Producer Turbine Wheel (Thicker-Walled Blades).

2.2.4.1. Results.

The gas-producer turbine wheel was in serviceable condition at the termination of test. Zyglo inspection revealed no cracks. The blades had experienced erosion (figure 4), but they met the serviceability criteria for erosion contained in Technical Manual 55-152-211-35 (reference 10, appendix I).

2.2.4.2. Analysis.

2.2.4.2.1. The modified turbine wheel is suitable and offers definite improvement over the standard assembly.

2.2.4.2.2. The thicker-walled blades have alleviated the cracking problem. The erosion was due to a combination of sand ingestion and combustion products.

2.2.5. Combustor Liner Mounting System (Flexible Studs and Solid Suspension Studs).

2.2.5.1. Results.

2.2.5.1.1. No bracket failures were observed during the test. It was discovered at final disassembly that the bracket in position 8 was broken (figures 5 and 6).

2.2.5.1.2. At disassembly, the solid suspension studs (without bushings) were in positions 2, 5, and 8. (The correct mounting positions are 1, 5, and 8.) A solid suspension stud is shown in figure 7 and a flexible mount stud in figure 8.

2.2.5.1.3. The liner had minor cracks at the cooling holes on the inner walls (figure 9). These were normal thermal relief cracks and did not affect the serviceability of the liner since the field-inspection criteria (reference 10, appendix I) were not exceeded.

Figure 4. Thicker-walled gas-producer turbine wheel blades.

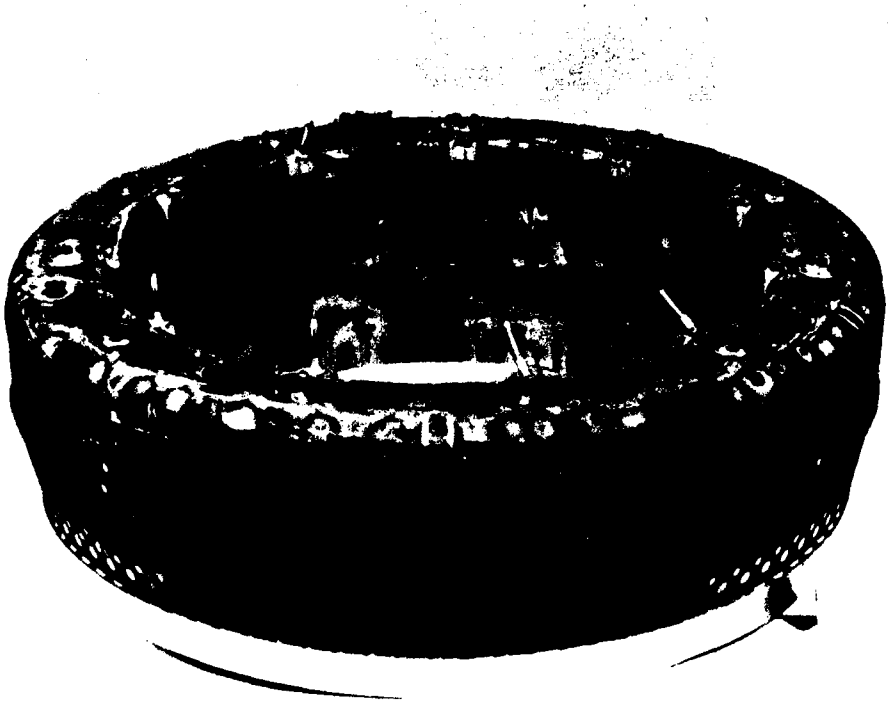


Figure 5. Combustor liner mounting system.

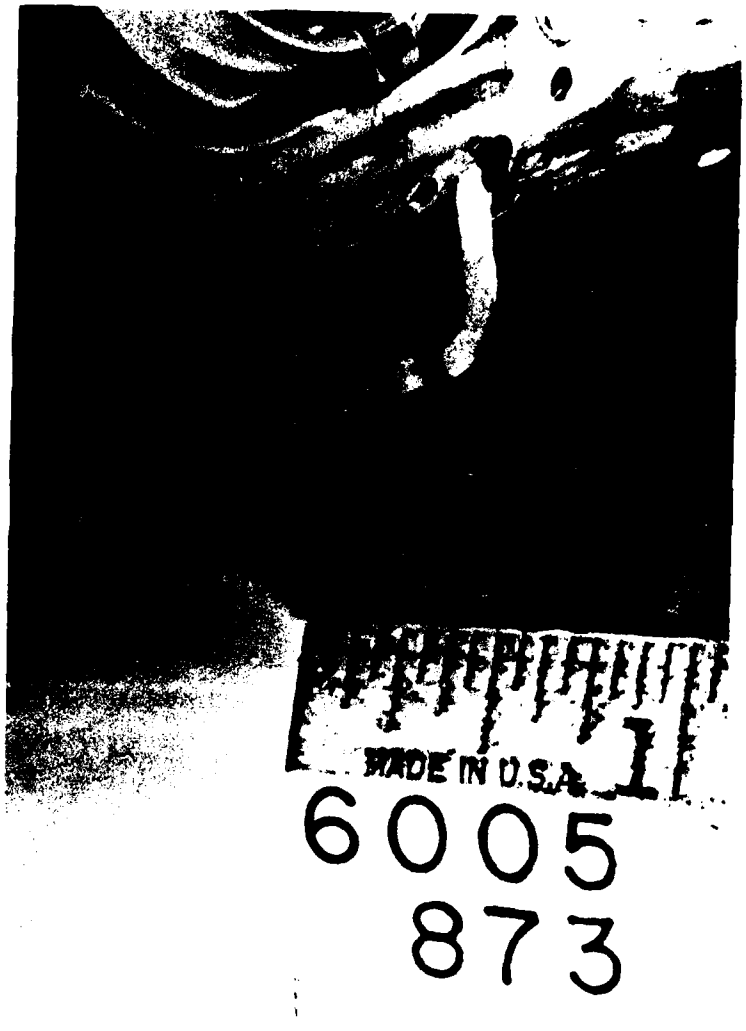


Figure 6. Broken bracket.

Figure 7. Solid suspension stud.

Figure 8. Flexible mount stud.

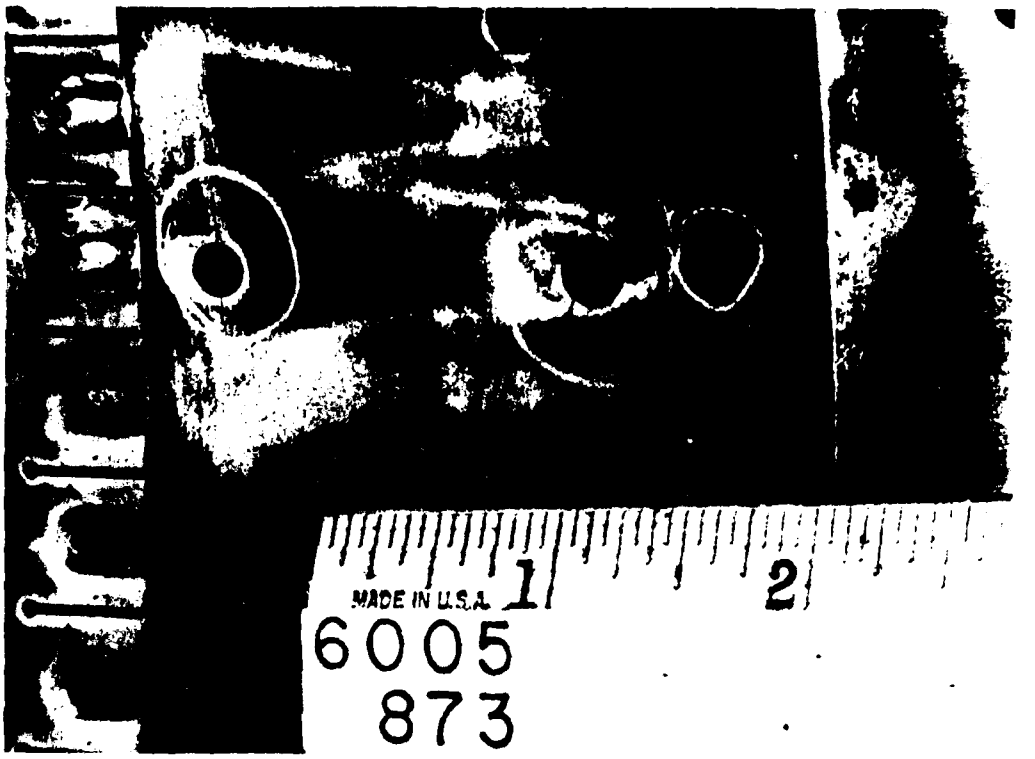


Figure 9. Cracks at the cooling holes on the inner walls of the combustor liner mounting system.

2.2.5.2. Analysis.

The incidence of bracket cracking was reduced in the assembly tested. However, one crack occurred in the solid suspension system and, in view of this, the suitability of the system cannot be determined without further testing. The effect of the incorrect position of the solid mounting system on the bracket failures was not determined.

2.2.6. Main-Shaft Carbon Seal (Repairable).

2.2.6.1. Results.

The carbon seal was operated during the test with no visible deterioration such as heavy coke streaks in the exhaust diffuser or smoke during shut-down. Failure of the power turbine bearing (No. 4), which ended the test, resulted in severe damage to the seal. Because of the damage, the carbon seal could not be analyzed during the tear-down inspection.

2.2.6.2. Analysis.

Suitability of this item cannot be determined and further testing is required.

2.2.7. No. 2 and No. 3 Main-Shaft Bearings.

2.2.7.1. Results.

2.2.7.1.1. The original No. 2 bearing was lost as a test item after 553 hours because of the replacement of the compressor section. The bearing installed as a portion of the new compressor attained 358 hours during the remainder of the test. No cage deterioration was evident, and the bearing rolls and races were in good condition (figure 10).

2.2.7.1.2. The No. 3 bearing operated throughout the test with light (normal) wear, but the rolls and races were damaged by particles from the failed No. 4 bearing (figures 11 and 12). The damage to the No. 3 bearing rendered it unserviceable.

Figure 10. No. 2 bearing rolls and races.

2.2.7.2. Analysis.

Because of the damage to the No. 3 bearing and the relatively-low operating time of the No. 2 bearing, suitability cannot be determined.

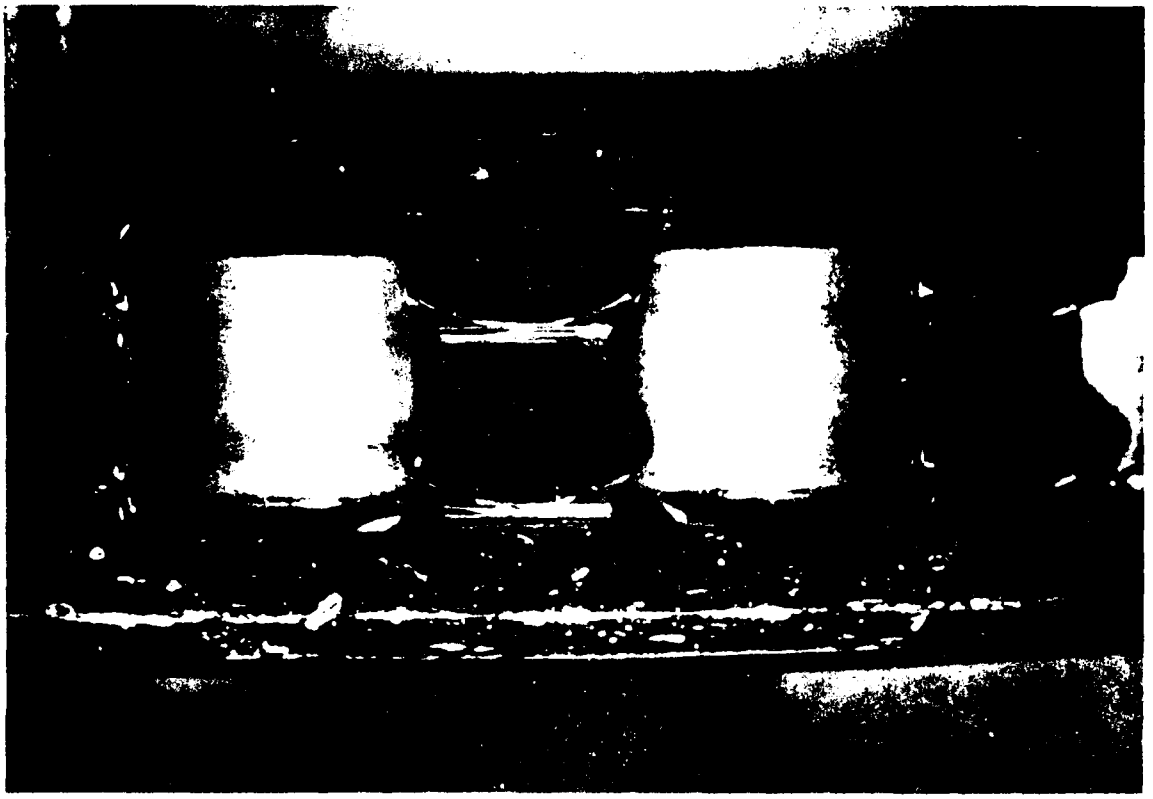


Figure 11. Dam[illegible] by [illegible] No. 8
bearing [illegible] Bearing
[illegible]

Figure 12. Damage sustained by the No. 3 bearing when the No. 4 bearing failed.

Figure 13. Strut-fairing leading edge of the diffuser.

2.2.8. Exhaust Diffuser (Stainless-Steel).

2.2.8.1. Results.

2.2.8.1.1. The strut-fairing leading edge of the diffuser cracked after 884 hours of operation. The cracks were welded and the part continued in operation. After an additional 57 hours of operation, the strut fairing was cracked at the leading and trailing edges (figure 13). Repair of the fairing was within the capability of the general-support maintenance category.

2.2.8.1.2. No rust was detected.

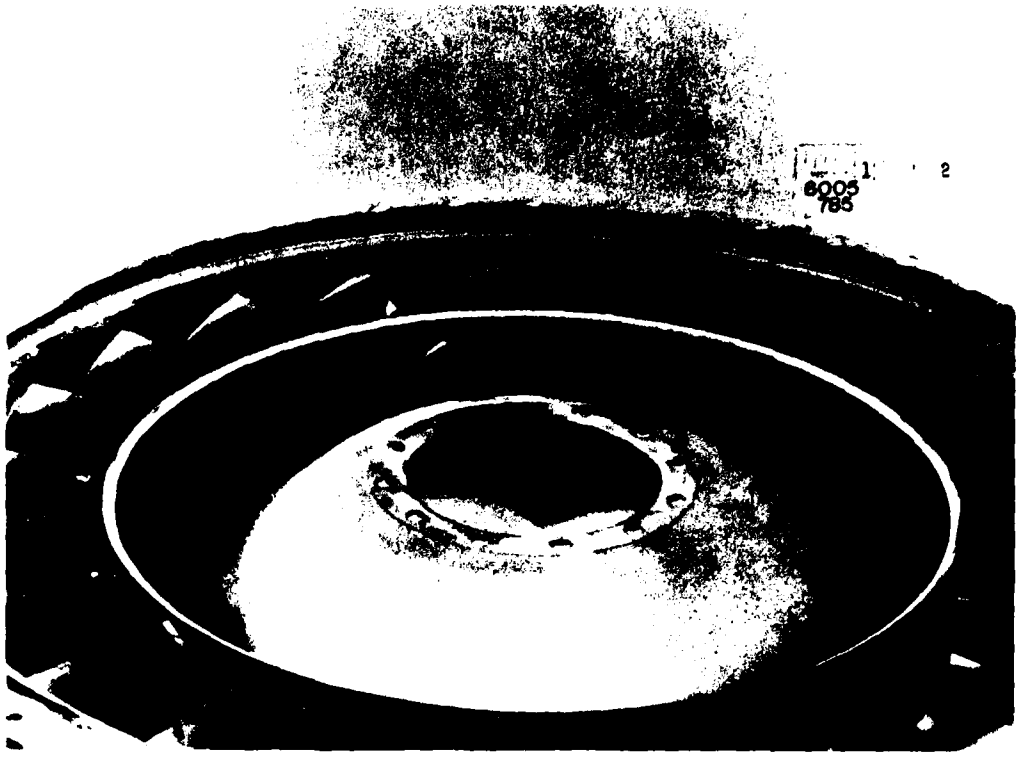


Figure 14. Damage sustained by the power turbine nozzle when the No. 4 bearing failed.

2.2.8.2. Analysis.

The exhaust diffuser is suitable and is a definite improvement over the standard assembly in that rust was not detected.

2.2.9. Power Turbine Nozzle (Depot Repairable).

2.2.9.1. Results.

The nozzle was operated throughout the test. Because of the bearing failure, it was scuffed heavily by the power turbine (figure 14)

Figure 15. View of the cracks in the outer-shroud vane brazements of the power turbine nozzle.

and was no longer serviceable. The nozzle was cracked in the outer-shroud vane brazements (figure 15). No cracks were evident on the inner shroud.

2.2.9.2. Analysis.

The modified assembly is suitable and offers a definite improvement over the standard assembly in that no axial cracking occurred in the inner shroud.

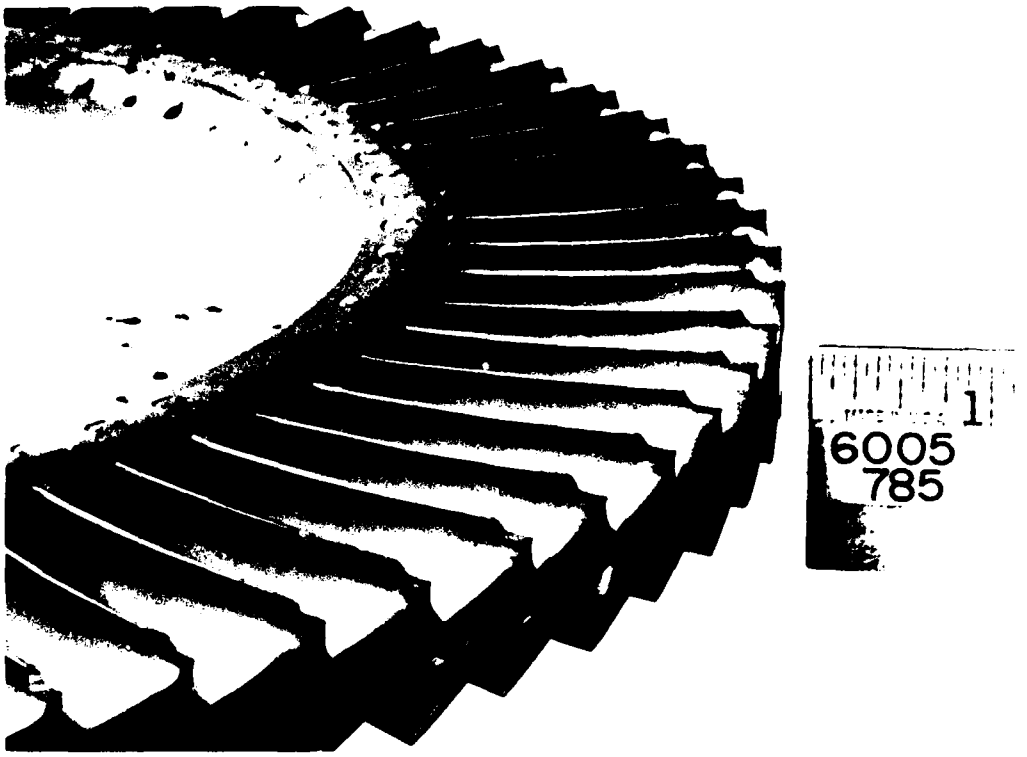


Figure 16. Damage sustained by the power turbine wheel when the No. 4 bearing failed.

2.2.10. Power Turbine Wheel.

2.2.10.1. Results.

The power turbine wheel was operated throughout the test. When the wheel moved forward during the bearing failure and contacted the power turbine nozzle, heavy scuffs were incurred at the disc face and the blade leading edges on the outer diameter (figure 16).

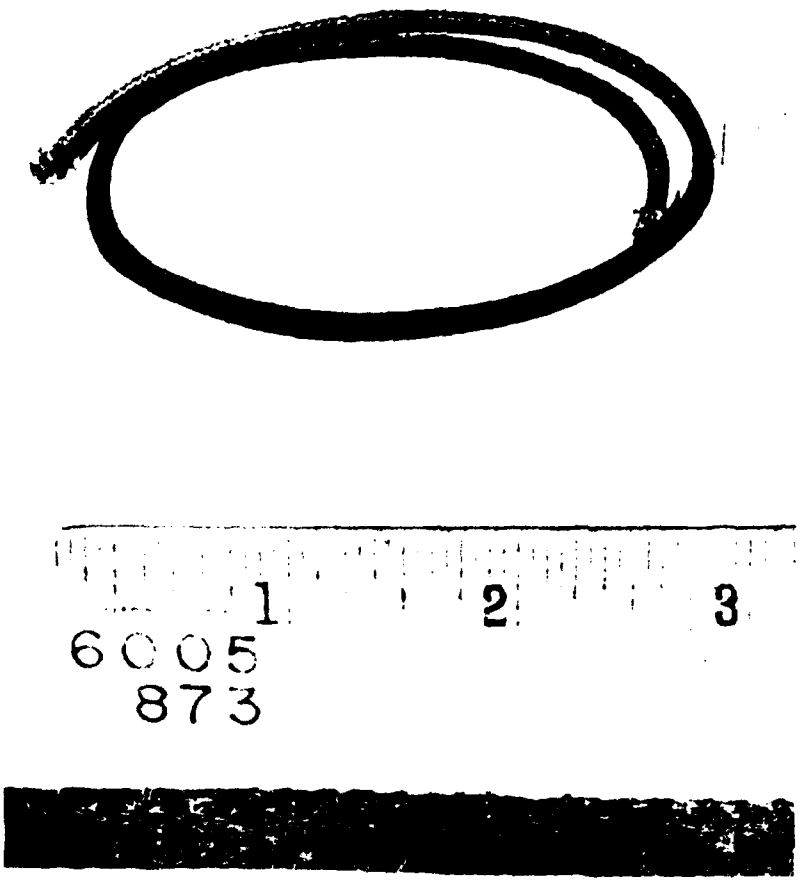


Figure 17. Asbestos air seal at the end of test.

2.2.10.2. Analysis.

Tip clearance* data were not valid because of the heavy scuffing incurred when the bearing failed. Therefore, suitability cannot be determined.

2.2.11. Asbestos Air Seal (Increased Diameter Wire).

2.2.11.1. Results.

The seal was in serviceable condition at the termination of the test (figure 17).

2.2.11.2. Analysis.

The air seal is suitable in that it did not require replacement during the test. The standard seal required replacement as often as each 300-hour hot-end inspection.

2.2.12. Air-Seal Segments (Increased Length).

2.2.12.1. Results.

The air-seal segments were still in serviceable condition at the end of test. The ability of the product-improvement components to prevent walnut-shell cleaning compound from becoming lodged between segments was not determined because the test was terminated before the engine was scheduled to be cleaned.

2.2.12.2. Analysis.

Although the segments were in serviceable condition at the end of test, the suitability of the seal segments as an improved item cannot be determined with this sample.

*Distance between outer edges of blades and power turbine cylinder.

SECTION 3 - APPENDICES

APPENDIX I - REFERENCES

1. Five-Hundred-Hour Progress Report, USATECOM Project No. 4-3-0150-06R, "Product Improvement Evaluation of UH-1D Helicopter," US Army Aviation Test Board, 23 January 1964.

2. Message, AMCPM-IR 3-1024, Commanding General, US Army Materiel Command, 5 March 1964, subject: "Product Improvement Evaluation of UH-1D S/N 60-6034."

3. Message, AMCPM-IRFO-T(E)-09-13867, Commanding General US Army Materiel Command, 28 September 1964, subject: "Product Improvement Evaluation of UH-1D S/N 60-6034, USATECOM Project 4-3-0151-06."

4. Message, AMCPM-IRFO-T(A)-11-13123, Comanding General, US Army Materiel Command, 24 November 1964, no subject.

5. Message, AMSTE-BG APG 20383, Commanding General, US Army Test and Evaluation Command, 10 December 1964, subject: "Additional Test Items for Installation and Test Under USATECOM Project Number 4-3-0150-06."

6. Message, AMCPM-IRFO-T(F)-12-13199, Commanding General, US Army Materiel Command, 10 December 1964, no subject.

7. Letter, AMCPM-IR-T, Headquarters, US Army Materiel Command, 15 December 1964, subject: "Submittal of Minutes of UH-1B/D Test Coordination Meeting."

8. Letter, AMSTE-BG, Headquarters, US Army Test and Evaluation Command, 27 January 1965, subject: "Test Directive, USATECOM Project No. 4-5-0151-( ), Product Improvement Test, UH-1D Items."

9. US Army Test and Evaluation Command Project Transcript Sheet, AMSTE-BG, 4 February 1965, USATECOM Project Number 4-5-0151-01, T53-L-11 Engine Product Improvement Items.

10. Technical Manual 55-152-211-35, "DS, GS, and Depot Maintenance Manual for Army Models YUH-1D and UH-1D Helicopters," 17 February 1965, as amended 2 August 1965.

11. Interim Report, USATECOM Project No. 4-3-015[illegible], "Continuation of the Logistical Evaluation of the YUH-1D Helicopter," US Army Aviation Test Board, 10 March 1965.

12. Minutes, Army/Navy, First Quarter FY 1964 TB3 Product-Improvement Review Meeting, 13 April - 15 April 1965.

13. Lycoming Report 1369.12.1, "Teardown Inspection of T53-L-11 Engine LE-06005X After Failure at Fort Rucker," October 1965

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4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final

5 AUTHOR(S) (Last name, first name, initial)

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	Iroquois Project Manager US Army Materiel Command Washington, D.C. 20315

13 ABSTRACT

As a result of the unsatisfactory performance of certain T53-L-11 engine components, the USAAVNTBD was requested to conduct a product improvement test of improved components on a T53-L-11 engine installed in a UH-1D Helicopter during the period June 1964 to December 1965. The test was terminated at the end of 941 hours of operation owing to damage resulting from failure of a bearing not being tested. It was concluded that the product-improvement items found suitable as replacements for the standard items in the T53-L-11 engine are the combustor deflector, gas-producer turbine wheel, exhaust diffuser, power turbine nozzle, and asbestos air seal; that other samples of the combustor liner mounting system should be tested to analyze further the cause of the one bracket failure; that the suitability of the product-improvement main-shaft carbon seal, No. 2 and No. 3 main-shaft bearings, and power turbine wheel cannot be determined because of damage sustained when the No. 4 bearing failed; and that the suitability of the design to air-seal segments to keep walnut-shell compound from lodging between segments cannot be determined because the engine was not cleaned with the walnut-shell compound. It is recommended that the product-improvement combustor deflector, gas-producer turbine wheel, stainless-steel exhaust diffuser, power turbine nozzle, and asbestos air seal be adopted as standard and incorporated in the T53-L-11 engines during production or overhaul; that additional samples of the product-improvement main-shaft carbon seal, combustor liner mounting system, No. 2 and No. 3 main-shaft bearings, and power turbine wheel be subjected to a 1200-hour test; and that the test of the air-seal system segments be continued to include cleaning the engine with walnut-shell cleaning compound. (U)

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KEY WORDS	LINK A	LINK B	LINK C
US Army Aviation Test Board	Power turbine nozzle		
Product-improvement test	Power turbine wheel		
T53-L-11	Asbestos air seal		
UH-1D/H helicopter	Air-seal segments		
Fuel Rocker	Suitability		
Compressor deflector	Serviceability		
Gas-producer turbine wheel	Walnut-shell compound		
Combustor liner mounting system	Erosion		
(flexible studs and solid suspension studs)	Cracking		
	Bracket failure		
Main-shaft carbon seal	No. 4 bearing		
No. 2 and No. 3 main-shaft bearings			
Exhaust diffuser			

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